Forestry Support Program

SHORT-TERM ECONOMIC BENEFITS OF AGROFORESTRY: A SURVEY

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I. EXECUTIVE SUMMARY

Increasingly the international development community is becoming aware of the important role that short-term economic benefits (those accrued during the first five years) play in peasant farmers' decisions to adopt agroforestry practices. This study is an effort to assess the current state of the art of agroforestry economics, in particular, the quantification of short-term, on-farm economic benefits of agroforestry. A review of the available literature identifies documents and studies which economically analyze several agroforestry practices and projects around the world. Additionally, a survey of informed sources provides an overview of on-going activities in the agroforestry economics field as well as identifies the principal players in the field.

It was found that research and documentation work in this field has been limited in scope and generally, piecemeal in nature. Of the studies examined, a majority are based upon either research station field trial data or tenuous assumptions made during pre-investment analysis, rather than on actual results from farm level interventions. Only a very few cases were identified where short-term economic benefits of agroforestry have been quantified. The document concludes with recommendations to the Forestry Support Program on specific interventions that can be made in the agroforestry economics field.

II. Introduction

During the past decade agroforestry has moved from relative obscurity to the forefront of the international natural resource management forum. The literature dealing with this "new" technology has been full of promises that agroforestry would revolutionize tropical agriculture by providing farmers in the less developing countries with more efficient and sustainable farming systems. Agroforestry would provide these farmers, experts claimed, with a cornucopia of benefits ranging from increased crop yields, a diversified production of farm and forest products and a more rational, sustainable use of soil and water resources. The 1980's agroforestry boom has been accompanied by a flurry of investment into agroforestry research, documentation, as well as field projects. As the years passed, however, some of the initial euphoria faded and agroforestry has come under greater scrutiny by the development community. Increasingly, policy makers, project planners, as well as field managers are demanding documented evidence of agroforestry's technical feasibility and economic viability. Recognizing also that the ultimate gauge of the success of agroforestry is the level of farmer acceptance and adoption, much of this interest in agroforestry economics has focused on the on-farm economic benefits of these practices.

The goal of this study is to assess the current state of the art of research on the short-term economic benefits of agroforestry. The underlying assumption guiding this work is that agroforestry's short term economic benefits (those accrued in the first five years of operation) play an important part in peasant farmers' decisions to adopt a particular agroforestry practice or system.

This study was conducted by means of a quick review of available agroforestry economics literature followed by a telephone survey of informed sources and potential participants in the field. Based on these findings, a series of recommendations are made to

the Forestry Support Program on potential interventions in the agroforestry economics field.

III. Economic Benefits of Agroforestry: An Overview

When a farmer makes the change from traditional agriculture practices to agroforestry he or she normally does so with the expectation of increased benefits or returns to the farm household. This improvement in farmer well being stems from agroforestry related increases in farm productivity. Figure 1, below, presents some of the productivity related on-farm physical changes that the various agroforestry interventions may produce.

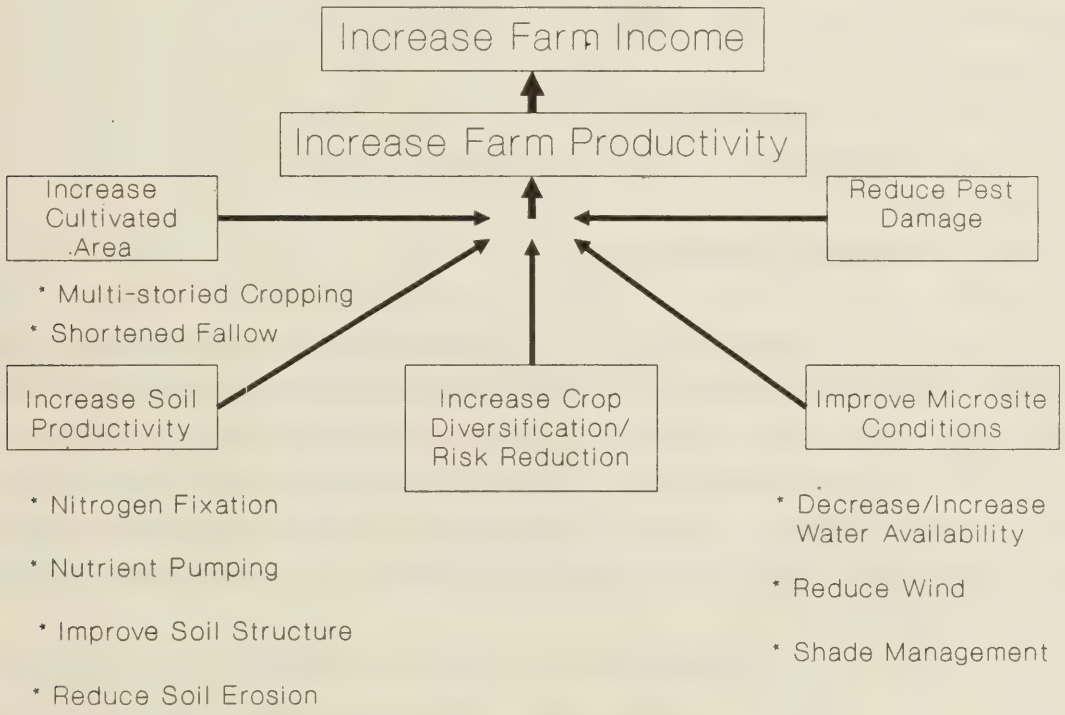

Figure 1. The Economic Benefits of Agroforestry

It is important to realize, however, that these benefits are not obtained without cost to the farmer. The economic costs that farmers face in adopting new agroforestry practices may include the following:

-increased labor requirements
-reduced cropping area
-increased pest damage
-loss of management flexibility
-increased competition
-high establishment costs
-increased harvesting costs

Any real assessment of agroforestry's impact on the smallholder must therefore examine both the systems' benefits and costs. Economic analysis provides the tools for comparing agroforestry related benefits and costs both from the farmers or society's perspective.

IV. Study Findings

A. Literature Review

The short duration of this study severely limited the number of publications that could be gathered and analyzed. The material that was obtained through local institutional and personal libraries does, however, provide a representative sample of the body of literature at large. The more valuable documents reviewed are classified into the following four broad categories and are summarized below:

1) Agroforestry economics bibliographies
2) Methodologies and issues in agroforestry economics
3) Agroforestry benefits in physical terms
4) Agroforestry benefits in economic terms

Bibliographies

Two important works that gather publications on the economics of agroforestry were obtained and examined in this study. Shapiro (1982) provides a long bibliographic listing of documents that deal loosely with the economics of agroforestry in developing nations. Hoekstra and van Gelder (1983, updated in 1985) have more closely screened references in their annotated bibliography which provides details of the type of economic information that each reference contains.

Methodologies and issues in agroforestry economic analysis

There is a fair amount of literature dealing with methods of performing economic analyses of agroforestry practices. These publications delve into the issues or obstacles that economists face when working on agroforestry project appraisal, such as discount rate selection, externalities, and shadow pricing. Probably the most prolific writer on this subject is D.A. Hoekstra from ICRAF who has published several articles on economic issues and methodologies (Hoekstra, 1983, 1985, 1985). William Magrath (1984) provides an in-depth study of special valuation problems involved in agroforestry as well as a valuable survey of economic returns to agroforestry projects. Works by Filius (1982), Harou (1983), Arnold (1984) and Betters (1988) also contribute to the theoretical study of economic appraisal of agroforestry projects.

Agroforestry benefits in non-monetary terms

Important efforts have been made in providing an indirect economic justification of agroforestry by presenting findings on the physical impacts of agroforestry practices. The following studies provide examples of these non-monetary benefits of agroforestry:

* McGahuey (1986) details the increases in crop yields in millet cultivated under Acacia albida in Sahelian Africa.

* In Nigeria the International Institute for Tropical Agriculture has conducted alley cropping trials that have shown dramatic increases in crop yield (IITA, 1984).

* P.K.R Nair (1984) describes improvements in soil fertility under different agroforestry systems.

* Anderson (1987) summarizes the effects of shelterbelts on crop yields in both developing and industrial countries.

* Liyanage et al (1989) describe the benefits of an integrated pasture, cattle and coconut farming system in Sri Lanka compared to coconut monoculture benefits.

After a cursory examination, it appears that there is a large body of this type of information available. While some consolidation of this material has been done (Nair, 1984, Chew, 1988), the constant flow of new research findings demands a constant updating of new developments. This task has seemingly been undertaken by ICRAF and academia.

Agroforestry benefits in economic terms

The term agroforestry generally refers to any number of potential farming systems that one encounters on a continuum running between "pure" agriculture and "pure" forestry. Defining when and where agroforestry begins and ends has kept scholars busy. This study also grappled with this definitional problem when

reviewing a number of documents dealing with what is termed **farm forestry**. Several of the best economic studies reviewed involve small, on-farm tree plantings or woodlots which fall in a grey area between agroforestry and traditional forestry. These studies, which tend to physically and economically isolate tree planting investments from other on-farm agricultural activities, are nonetheless valuable in assessing the positive return that tree production can have on a farm's budget. The following are some of the more complete and valid economic work done on farm forestry projects:

* Gregersen and Contreras (1979) present a detailed economic and financial analysis of smallholder tree plantations in the PICOP project in the Philippines.

* Hosier (1987) conducts an ex ante analysis of the Kenya fuelstick project and compares it to a more conventional woodlot project option.

* Energy/Development International (1986) provides case studies in eight countries on the economics of private tree farming for fuelwood production.

* Anderson (1987) presents an ex ante economic analysis of a farm forestry project in northern Nigeria.

* Navarro and Reiche (1985) conduct an ex post financial analysis of a family plantation of Gliricidia sepium in Costa Rica for fuelwood production.

* Newcombe (1984) studies ex ante the economic benefits of rural afforestation in Ethiopia derived from substituting animal dung with fuelwood and the associated increases in crop yields.

In examining more clearly defined agroforestry systems several important economic studies were identified. These studies are summarized below, according to agroforestry system. In most cases it is noted whether the study was prepared before project implementation was initiated (**ex ante** analysis) or prepared after field work was underway using actual field data (**ex post** analysis). The importance of this distinction is discussed later in the paper.

Live fencing

* Reiche (1984) summarizes an ex post study conducted in Honduras which compares the economics of Gliricidia live fences with dead post fencing.

* Reiche (1988) again presents summary ex post economic data on Gliricidia live fencing investment in Central America by the Madelena project.

Alley cropping

* Kass, et al (1989) reviews economic results from 6 years of field research (ex post) on alley cropping in Turrialba, Costa Rica

Shelterbelts

* Anderson (1987) provides an ex ante benefit-cost analysis of a shelterbelt project in northern Nigeria.

Intercropping

* Mathur et al (1984) presents an ex ante benefit-cost analysis of block and bund planting of Eucalyptus

intercropped with wheat and paddy.

* Khan and Better (1989) perform an ex ante economic analysis of agroforestry options for small irrigated farms in Punjab, Pakistan finding the most efficient single crop and joint poplar-wheat production possibilities.

* Gupta (1982) estimates ex ante the returns from a silvo pastoral system of pasture grasses and multipurpose tree crops in Rajasthan, India.

* Reiche (1984) summarizes the findings of an ex post field trial in Costa Rica where Eucalyptus on a 3 year rotation was intercropped with corn to produce fuelwood for small sugar refineries.

* Shekhawat et al (1988) examines ex post the intercropping of Acacia tortilis with fodder crops in Rajasthan, India.

* Grosenick (1986) conducted an in depth ex post economic analysis of the Agroforestry Outreach Project (AOP) in Haiti. In addition to a project wide analysis his study also examines the economic return to farmers who plant project trees in their gardens.

* Van Eysinga (1989) provides an updated evaluation of the AOP project in Haiti.

Temperate agroforestry

While the focus of this study was the economics of agroforestry in developing countries several documents were reviewed that detailed research findings in industrial countries.

* Reid and Wilson (1985) review a number of economic studies on the profitability of grazing under wide spacing of Pinus radiata in Australia and New Zealand.

* Kurtz and Garrett (1989) provide a financial analysis of an ongoing agroforestry project in Missouri, USA where Juglans nigra is intercropped with wheat and soybeans.

B. Principal players in the economics of Agroforestry field

As a second step in assessing the state of the art of agroforestry economics a survey was conducted to establish who were the principal players in the field. This survey was conducted by means of personal contact with informed sources. Eventually over 25 reference people were contacted at 20 institutions (appendix 1). This survey resulted in the following listing of the main institutional players in the agroforestry economics field. Contacts at these institutions as well as a brief description of past or present activities is also provided.

Note: As several of these institutions and individuals proved to be very difficult, if not impossible, to contact during this short study, information about their involvement in the field comes secondhand. Given this situation the author therefore apologizes for any gross, or minor errors (misspelling of names) in this overview. In addition, due to the nature of inter-institutional linkages in international development work it is highly likely that certain players listed below are simply contractors for major players rather than being independent participants.

Institution	Key Contact	Activities
	Research Organizations	
ICRAF Kenya	D. Hoekstra S. Scherr A. Getahun	Ongoing economic studies of alley cropping and other systems in East Africa. Conducting an in-depth assessment of the state of the art of agroforestry economics
CATIE Costa Rica	C. Reiche	Ongoing economic studies of a network of demonstration sites throughout Central America. Different economic studies undertaken by graduate students for thesis work.
IITA	B.T. Kang	Ongoing economic examination of alley cropping system in Nigeria
ILCA	K. Atta-Krah L. Reynolds	Alley cropping and browse production economics
ICRISAT	Thomas Walker	Household-level economic analysis of agroforestry
	C.K Ong	Economics of alley cropping spacing in India.
	R. Van den Beldt	
	Universities	
Oxford	J.E.M. Arnold	Agroforestry economics methodology and issues
	P. Dewees	Economics of agroforestry adoption in Kenya.
Cornell	P. May	Phd work studying the economics of babassu palm in Brazil

SUNY Syracuse		Phd work on economics of multipurpose trees
U.C. Berkeley	J. Romm	Economic aspects of agroforestry adoption in south and southeast Asia
U. Philippines Los Banos	C. Cruz	
Kasetsart U. Thailand	Y. Chalamwong	Economics of tree products use on the household level

Donor agencies/Multilateral lenders

USAID		Some economics studies done by contractors for the agency's ongoing agroforestry projects
World Bank		Occasional studies of agroforestry projects and methodology
IDB	S. McGaughey	Pre investment economic analyses of some projects containing agroforestry components

C. Survey Conclusions

1. The work done on the economics of agroforestry has been scanty and piecemeal in nature.

The primary reason for the slow rate of progress in this field is that an economic analysis of a particular agroforestry system requires the quantification of that system's many bio-physical relationships, i.e. accurate assessment and understanding of an agroforestry systems' physical inputs and outputs. With few exceptions agroforestry research has yet to come up a clear understanding of the dynamics of the numerous systems and practices. Progress in agroforestry economics is, therefore,

dependent upon, and lags behind basic agroforestry field research work.

Another issue which, unfortunately, could not be adequately addressed in this study was the quality of work done in this field. Anyone with a basic understanding of economic analysis recognizes that the majority of these studies are based upon certain pre-established assumptions. Based on the documentation reviewed in this study it was virtually impossible to evaluate the legitimacy of the assumptions made in each case. The author,therefore, makes no attempt to gauge the relative strength of individual studies and the body of literature as a whole.

2. There are very few examples in the literature where short-term benefits of agroforestry are quantified.

In general this study found that, with few exceptions, economic analyses of agroforestry practices have quantified long-term benefits (accrued by the farmer after 5 years), rather than short term benefits. The following studies do, however, quantify benefits received by the farmer in the short term (see appendix 2 for detailed study findings).

* A cost benefit analysis on 12 agroforestry and 8 traditional cropped plots in Thailand found a Eucalyptus and cassava intercropping scheme on a three year rotation to be the most profitable (Wannawong and Belt, 1989).
* Eucalyptus (3 year rotation) with corn intercropping in Costa Rica provides greater returns than a tree planting alone (Reiche, 1984).
* Gliricidia sepium live fencing provided cost savings over dead post fencing (Reiche, 1984).

The fact that that there are relatively few studies documenting short-term benefits does not, however, indicate that

farmers obtain only long-term benefits from agroforestry. This scarcity of short-term benefit documentation is in part a reflection of the types of agroforestry systems that are being appraised and the current state of the art of agroforestry economics.

The majority of economic studies of agroforestry reviewed in this paper identify returns from wood products, such as poles, timber, and fuelwood, that were harvested later than 5 years. These studies largely ignore, however, returns from regular, small harvests of fuel and fodder from branches that small farmers tend to make prior to the final tree harvest. Other studies which identify economic returns related to improvements in cropping microclimate, as in the case of windbreaks and nurse trees, also tend not to identify short-term economic benefits. In these cases farmers must usually wait until trees reach a certain size or height before benefit flows become significant.

Agroforestry systems that produce outputs such as fodder, green manure, small diameter fuelwood or other products, as in the case of alley cropping systems or live fencing, can potentially produce greater benefits in the short-term. While work at ICRAF, IITA and CATIE have made great strides in the quantification of benefits in alley cropping, the bulk of the work has been done on research station plots, not real-life farm level plots.

In summary, it is expected that as economic analysis of agroforestry practices becomes more complete and rigorous, and more of the range of agroforestry systems are appraised economically, we will find greater evidence of agroforestry's short-term economic returns.

3. Coordination and communication within the agroforestry economics field is lacking.

It is clear from discussion with researchers and interested observers that the exchange of information and findings within the

field is poor. The problem exists on two important levels. First, on the level of researchers who are often unaware of other work being done in the field, and second, on the policy making and field implementation level, where poor information transfer limits the application of potentially valuable research findings.

4. There is a great lack of assessment of the economic impact of agroforestry at the smallholder farm level.

This study found that only a small part of the agroforestry economic research to date has been carried out at the farm level. Given the informational constraints mentioned above researchers have tended to conduct analyses based on data obtained from research station plots or tightly controlled demonstration gardens. While these studies are valuable in themselves it is critical that research efforts leave the sterile confines of research stations to assess the impacts of agroforestry under more realistic conditions of the smallholder's farm.

5. There is a shortage of ex-post economic analyses of agroforestry systems

The majority of the agroforestry economic analyses carried out to date have been done ex-ante, or before any project implementation. These studies attempt to anticipate a project's economic feasibility using the best available data. Most often this information comes from experiences in research stations or other projects, many times in other countries. While these studies are important in obtaining funding for a project, their results often differ greatly from actual implementation results. If agroforestry investment is to be justified from an economic standpoint more work needs to be done ex-post using real project results.

V. Recommendations to the Forestry Support Program

1. Provide an in-house seminar/planning session on agroforestry economics

In discussing what role the Forestry Support Program (FSP) should play in the field of agroforestry economics it is critical that FSP should first examine the issue internally so as to develop an institutional strategy. It is important to realize that any serious effort in the field would almost certainly involve all parts of FSP, from regional coordinators to all technical specialty coordinators. Therefore, it is critical that any discussion or strategy development include all professional office staff. In addition to summarizing this study's findings this planning session should touch upon the following issues:

a. The relative importance of agroforestry economics to USAID, USDA and the international natural resource management community, i.e. the potential demand for any action.

b. What type of financial and personnel commitment is FSP willing to make to work in the agroforestry economics field.

c. What actions are feasible and most cost effective for FSP to undertake.

d. Individual contributions and responsibilities in this effort.

These internal discussions could be led by Susan Huke, the agroforestry specialist. Pat Durst's strong economics background could make a strong contribution. The following recommendations

provide a variety of options or interventions that may be acted upon depending on FSP's desired level of involvement or commitment.

2. Establish closer ties with main players in the agroforestry economics field and promote greater professional networking

This review represents FSP's first major step or involvement in the agroforestry economics field. A logical next step would be to expand contacts and solidify ties with the institutional and individual participants active in the field. Once a better understanding of this network is achieved, FSP will be better able to plan effective interventions in the field. From the outset, it appears evident that FSP's mandate, as well as its limited financial and personnel resources would preclude any **major** role in agroforestry economics research efforts in the field. FSP would be effective, however, serving as a catalyst and intermediary promoting better communication and coordination between investigators as well as aiding the spread of information to interested parties, such as field personnel and policy makers. Playing this role within such a professional network FSP might consider the following interventions.

a. Gather agroforestry economics reports and resource materials

Given that there are relatively few references related to this field and are often difficult to obtain FSP would make a valuable contribution by gathering existing materials as well as new studies as they become available. This action which has already begun with this study, would require little effort and would provide a valuable resource to researchers, field personnel and policy makers.

b. Promote the spread of agroforestry economics information.

FSP's far reaching quarterly newsletter provides an excellent forum for bringing new studies or papers on agroforestry economics to the attention of interested individuals and institutions. Ongoing work and recent study findings should be reviewed and highlighted. Should this use of the newsletter be inconsistent with its purpose, the possibility of initiating a newsletter (published quarterly or biannually) dedicated solely to summarizing new developments in the field should be explored. This work could be done in conjunction with an institution such as ICRAF whose existing network would greatly increase the information gathering and exchange potential.

3. Stimulate the development of more <u>ex post</u> economic case studies of agroforestry systems.

The importance of valid economic case studies for the purpose of evaluating and promoting agroforestry is clearly recognized by the development community. A positive contribution by FSP would be to encourage the development of these case studies. Before any work in this direction can begin, however, an effort must be made to define more clearly what are the specific goals of these case studies, i.e. what international policy changes, if any, are these case studies attempting to stimulate? Are these case studies expected to;

1. Demonstrate to the development community the economic viability of agroforestry as a general land use practice and thereby increase interest in greater sectorial investment? or,
2. Identify particularly successful agroforestry practices in order to stimulate greater investment into the

development and promotion of these practices in certain geographic areas?

3. Achieve any other important objectives?

Once the role of these proposed case studies has been established it will be much simpler to formulate a case study development strategy. In developing this strategy the following avenues or interventions should be explored:

a. Develop a standardized economic case study format for different agroforestry systems

A frequent obstacle encountered by field personnel wishing to appraise a particular agroforestry system is that of determining which physical changes or impacts should be examined. In order to facilitate both the gathering of field data and the comparison of results between experiences it is critical to standardize data collection strategies and methods. In consultation with the professional community FSP could prepare a practical guide for field researchers describing which factors might best be examined and how they should be measured for the primary agroforestry systems. The following provides examples of possible measures to be quantified for some agroforestry systems:

Agroforestry System	Measures
Alley cropping	Change in crop yields Fodder production
Windbreaks	Change in crop yields Improved crop quality

Live fencing	Fodder/mulch production
	Fuelwood production
	Replacement cost savings

The development and distribution of this type of manual to field personnel as well as project planners could greatly improve the effectiveness and usefulness of information gathered in the field. And consequently, result in more and better case studies.

b. Identify and develop potential case studies

In identifying particular agroforestry systems with economic case study potential FSP would be well served to take advantage of its close relationship with USAID, Peace Corps and other development organizations. It is likely that these organizations have in their portfolios ongoing agroforestry activities or projects that have already gathered sufficient field data so as to complete valuable case studies, yet lack only the time or expertise to conduct an economic analysis. During this study one such situation was identified: Ms. Tara Kidd, a former North Carolina State graduate student, has accumulated a substantial body of cost and yield data about alley cropping in Western Samoa yet had not conducted an economic analysis. There are other agroforestry systems around the world that might prove to be likely case study material simply because of the years of experience and investigation behind them. Examples of these potential agroforestry system case studies include:

1) Sloping Agricultural Land Technology (SALT), especially work done by the Baptists in Mindinao, Philippines.

2) Silvo-pastoral systems currently in use in Central America.
3) Intercropping/tree cropping by peasant farmers in Haiti.
4) Windbreaks in West Africa, notably Niger and Nigeria.

Information about these and other potentially valuable case study examples could possibly be gathered through requests directly to particular AID missions or through general announcements in FSP, AID or other institutional newsletters distributed to field offices. In order to avoid a potential deluge of inappropriate responses or information from these announcements careful consideration must be made in establishing the criteria for selecting case study material before a published request is made. Selection of sites or agroforestry examples where case studies might be developed should be based on a clear set of criteria. The following questions could provide guidance in establishing such a selection criteria:

1) Is the agroforestry example consistent with the overall case study strategy (as discussed earlier in the paper)? i.e. has it been decided which agroforestry systems should be studied? Is it more desireable to have single case studies of as many of the agroforestry systems as possible, or should several studies be done on a few major systems?
2) Does there exist enough field data to conduct an valid economic analysis? i.e. information on the costs of establishment and management of the systems, crop yield and other production data for both the agroforestry practice and the traditional farming system it replaces.
3) Is the information available of acceptable quality?

4) Are there any readily available resources such as other projects or research centers that may aid in filling any of informational gaps in the analysis?

5) Does the example provide valuable lessons which may be transferred or be applicable in other countries or regions.

Once potential case studies have been identified the actual analyses and case study preparation could be performed by internal staff economists (in the case of AID), by outside consultants or, possibly, by graduate students familiar with economic analysis techniques. Given FSP's prior experience with student interns this avenue should be explored further in order to obtain the desired services.

4. Improve agroforestry project monitoring and evaluation methods

FSP should work with AID and other institutions to improve agroforestry project design and monitoring so as to facilitate economic evaluations of both agroforestry projects and on-farm impacts of agroforestry interventions. According to sources efforts to this end are underway within AID's Africa program and policy evaluation section. While institutional policy changes on project monitoring and evaluation procedures tend to be private internal decisions FSP might provide input into the process through the development of the above mentioned agroforestry impacts assessment manual.

5. Adapt and promote the use of economic analysis computer software packages

If economic analysis is to be used more frequently to evaluate the effectiveness of both farm level agroforestry interventions and larger agroforestry programs efforts must be made to demystify and

simplify this appraisal process. While there are no shortcuts in assembling the cost and benefit data needed for this analysis the widespread use of microcomputers in the development field promises to make the economic analysts' job much easier. At the present time there are a number computer software packages that greatly simplify economic analysis of projects, particularly the laborious calculations that these analyses involve. While the author is presently aware of only two such programs, CASH and MULBUD, it is likely that other similar programs exist.[1]

MULBUD is a computer package developed by the Australian National University for the economic analysis of multi period and multi enterprise farm budgets. The package has been field tested for agroforestry applications by D.A. Hoekstra at ICRAF in Kenya. While the author was unable to obtain a copy of this program during this study a paper by Hoekstra (1983) provides an idea of the program's capabilities and effectiveness. In this study Hoekstra uses MULBUD to conduct an economic analysis of a simultated alley cropping system.

CASH is a forestry investment computer package developed by the University of Minnesota. This program enables the analyst to compare investment alternatives using criteria such as the present net value, internal rate of return, payback period, risk and sensitivity analysis. While this program was designed for forestry applications it readily lends itself to simple agroforestry situations and projects as illustrated by a hypothetical case study conducted by the author (Jickling, 1986) (available from FSP). A study by White (1989) also details the use of the CASH program in the economic appraisal of a watershed management project in Haiti.

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[1] Information from Winrock International indicates that economist Lee Medema with the F/FRED project is currently examining the different commercially available economic analysis software.

Should there be interest in this program it should be possible to make small changes in the program format so as to improve its use for agroforestry situations. For example, the programs current demonstration exercise which involves investment in Christmas trees might be changed to a living fence or alley cropping investment example.

If after evaluating the potential usefulness of these and other software packages FSP wishes to encourage their increased use the first step would be to contact the software developers to arrange for adaptation and distribution of the programs. Promoting the software could be done once again through the FSP, and possibly AID, newsletters. Note: ICRAF has already somewhat publicized the MULBUD program through their journal. As part of this extension work efforts should be made to reach private voluntary organizations involved in agroforestry activities. Positive responses from these initial efforts could lead to the development of short programs or seminars on the use of economic analysis packages for interested parties within the development community.

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Appendix 1: Individuals interiewed - Sept - Oct 1989

Sarah Scherr	ICRAF/Kenya
Dean Current	CATIE/Costa Rica
Robert Winterbottom	WRI/CIDE
Hans Gregersen	University of Minnesota
Patrice Harou	University of Massachusetts
David Betters	Colorado State University
William Kurtz	University of Missouri
Richard Hosier	University of Pennsylvania
Michael Gold	Michigan State University
Jan Laarman	North Carolina State
P.K.R Nair	Univ of Florida
Jeff Romm	Univ Cal Berkeley
Bill Macklin	Nitrogen Tree Fixing Asso
Tara Kidd	Forest Nutrition Center
Doug McGuire	Forestry consultant/World Bank
Andy White	Save the Children Federation
Scott Josiah	Pan Amer Devt Foundation/Haiti
Dennis Johnson	Tropical Research and Devt
Sandy Hale	IRG/EDI
Michael Benge	USAID/S&T/FENR
Michael McGaughey	USAID/AFR/TR/ANR/NR
William Beatty	World Bank
A.J. Banerjee	World Bank
Steve McGaughey	Inter-American Devt. Bank
Bruce Burwell	Peace Corps
Susan Huke	Forestry Support Program
Pat Durst	Forestry Support Program
Kathryn Hunter	Forestry Support Program
Tim Resch	Forestry Support Program

APPENDIX 2: SHORT-TERM BENEFITS CASE STUDIES

APPENDIX 2.1

Association of Eucalyptus saligna with Zea mays to provide fuelwood for one "trapiche" in San Ramón, Costa Rica

The "trapiches" are small rural processing plants which utilize fuelwood and sugar cane residues for concentrating sugar cane juice in order to produce "dulce", an unrefined sugar. The production volume in the "trapiche" which was studied, is about 156,000 $kg.a^{-1}$. This results from the processing of 17 mt of sugar cane (Saccharum officinarum) per day. Every week about 5.8 m^3 of fuelwood (stacked) are used (302 m^3 stacked $fuelwood.a^{-1}$). The fuelwood is extracted from secondary forests of the farm where the "trapiche" is located. However, there will be future supply problems unless fuelwood plantations are established (11).

As a response to this need, in 1982 the owner established a small agroforestry plantation (0.55 ha). Initially he planted corn (Zea mays) at a spacing of 2.00 by 0.84 m (3 seeds per planting hole = 17,857 $plants.ha^{-1}$). After the germination of the Z. mays he planted E. saligna at a spacing of 2.00 by 2.00 m (2,500 $trees.ha^{-1}$) and he fertilized each tree with 40 g 10-30-10 (N-P-K). After the harvesting of the Z. mays he planted 2 rows of tiquisque (Xanthosoma spp.) between the tree rows. However, this crop failed because of the shade produced by the E. saligna.

The establishment and maintenance cost data were systematically collected from the beginning of the plantation, and the evaluation of growth and exploitation was carried out after 30 months. The oven dry firewood yield was 41.3 $mt.ha^{-1}$ (16.5 $mt.ha^{-1}.a^{-1}$). The total oven dry biomass yield was 53.9 $mt.ha^{-1}$ (27.7 mt $ha^{-1}.a^{-1}$). In terms of stacked green firewood, the yield was 160 $m^3.ha^{-1}$, equivalent to 64 $m^3.ha^{-1}.a^{-1}$ (11). However, the "trapiche" needs 302 $m^3.a^{-1}$. In other words this means that there is a need to manage a total area of 5 ha under forest production, assuming the same annual yield with 3 year rotations under an adequate coppice management. The yield of the Z. mays in the 1st. year was 500 $kg.ha^{-1}$.

Based upon these costs and the yields, a financial analysis was carried out considering only the first cycle. A discount rate of 10% and present price of ¢ 250.m^3 of stacked firewood were used.

The association not only has a high technical feasibility, but also from a financial point of view it is a desirable alternative, since for each colon invested there is a profit of 0.11 (Table 3). In addition, the IRR was higher than the current bank interest rates in Costa Rica. An advantage of this kind of agroforestry system is the production of food and income from the annual crops, the latter helping to reduce forestry plantation costs. When the annual crop is not present (sensitivity analysis), financial indicators show clear reductions. In the above case only small differences were observed because only one annual crop harvest was possible. Nevertheless, with more appropriate inter-tree spacing, it would be possible to obtain more than one harvest from the annual crops during each forestry rotation.

Table 3. Financial indicators for the agroforestry association of Eucalyptus saligna-Zea mays, San Ramón, Costa Rica (3 year rotations; costs in $colones.ha^{-1}$)

Indicators	With Zea mays (Discount rate 10%)	Without Zea mays (Discount rate 10%)
Present net value ($C.ha^{-1}$)	3,830	3,211
Benefit/cost ratio ($C.ha^{-1}$)	1.11	1.10
Internal rate of return (%)	20.15	18.50

Cost-Benefit Analysis of Selected Agroforestry and Monocropping Systems in Northeastern Thailand (Phu Wiang Watershed, Khon Kaen Province)

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ABSTRACT

Increasing numbers of shifting cultivationists in the Phu Wiang watershed in northeastern Thailand threaten the ecological stability and productivity of the region. The Royal Forest Department, RFD, in collaboration with the FAO/UNDP is seeking ways to institutionalize sedentary agriculture and is evaluating agroforestry as an alternative. Research data from the Phu Wiang watershed, supplied by the Phu Wiang Watershed Project, are used in this study to compare traditional cropping systems with alternative agroforestry systems. Agroforestry systems studied consisted of combinations of either *Eucalyptus camaldulensis*, *Leucaena leucocephala*, or *Acacia auriculiformis* intercropped with cassava (*Manihot esculenta*) or mungbean (*Vigna radiata*). The traditional monocrops used in comparison were cassava and mungbean.

A cost-benefit analysis was made on 12 agroforestry and 8 traditionally cropped plots using the MULBUD computer program. Results of this analysis suggest that agroforestry systems can provide greater financial return than traditional cropping systems. The most profitable agroforestry system intercropping *Eucalyptus camaldulensis* (spacing 2m x 8m) with cassava gave a SNPV of 4,560.28 baht/rai on a 3 year rotation while that obtained from cassava alone was 2,807.07 baht/rai at a discount rate of 8%. Sensitivity analysis suggests that the financial return of *Eucalyptus camaldulensis* (spacing 2m x 8m) combined with cassava is still greater than that of pure cassava compared by using the SNPV derived from four different discount rates (5%, 7%, 9%, and 11%) and the changes in material costs and gross revenue by 10% and 20%.

Live fences of Gliricidia sepium (Jacq.) Steud in the North-east of Honduras

The information for this analysis was taken from a document about the management and production from living fences, presented by Otárola and Martínez (7). It should be noted that many of the costs and yields (in time) are hypothetical, but are based upon field experiences.

As an agroforestry system, living fences constitute an alternative for small producers with land constraints for the establishment of pure plantations, and for medium and large producers who have more land, but who concentrate on other agricultural or animal production activities.

The research was carried out in the San Antonio farm in the Department of El Progreso, Honduras. A financial analysis was carried out using yield information, establishment costs, maintenance and harvesting costs. The information (Table 4) shows high establishment costs, principally the investment in wire and other materials. The financial analysis of the inputs and outputs, over a period of 9 years, shows a present negative net value of L 445.km^{-1}. This is due to high fence maintenance and coppice sprout management costs. However, in the case of a fence with dead posts, the farmer must pay out L 3,293.km^{-1} establishment costs without ever receiving any secondary benefits or income from the fence. Moreover, since the fence with dead posts will only last 5 years, this establishment cost is cyclical. Thus, in the case of live fence posts the farmer reduces his costs to one seventh of the total costs for the maintenance of fences with dead posts.

Table 4. Financial indicators for a live fence of Gliricidia sepium, and for a fence with dead posts in San Antonio, Honduras (Costs in Lempiras.km^{-1})

INDICATORS	LIVE FENCE (Discount rate) 10%	FENCE WITH DEAD POSTS (Untreated posts lasting 5 years)
Establishment cost (L.km^{-1})	2,861	3,293
Present net value (L.km^{-1})	-445	--
Benefit/cost ratio (L.km^{-1})	0.90	--
Internal rate of return (%)	6.19	--